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Title	Some Issues of Accommodation of TG1 MAC at TG3	
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Re:	This document contains references to some issues that should be resolved for further progress in the direction to TG3 MAC given TG1 MAC as a baseline	
Abstract	The following issues considered: <ul style="list-style-type: none"> - MAC-PHY Separation - Parameters and Constants from TG1 MAC - Frame Structures - Constants and Content of Messages Related to Performance, Delays, QoS - TG3 Specific Features 	
Purpose	To figure some issues that should be resolved for further progress in the direction to TG3 MAC	
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1. Goal of the Document

This document contains references to some (not all) issues that should be resolved for further progress in the direction to TG3 MAC given TG1 MAC as a baseline.

Naftali Chayat made some important contributions to this document.

2. References

- [1] IEEE 802.16.1-00/01r4, September 2000. Air Interface for Fixed Broadband Wireless Access Systems
- [2] IEEE 802.16.3-00/02r4. Functional Requirements for the 802.16.3 Interoperability Standard
- [3] A Behavioral Model of Web Traffic, Hyoung-Kee Choi, John O. Limb. Georgia Institute of Technology, 1999
- [4] The nature of the beast. Recent traffic measurements from an Internet Backbone. By Greig Miller and Kevin Thompson, 1997.
- [5] IEEE 802.16.1mc-00/19 Specifying an ARQ mechanism for 802.16.1 MAC layer. By Yigal Leiba

3. MAC-PHY Separation and PHY Convergence Layer Procedures

3.1. Motive

Even today the TG1 Air Protocol has multiple PHYs. Now we are going to add at least one more (HUMAN: 802.11a/HIPERLAN2-like OFDM). This is an example of PHY which is seriously different from TG1 PHYs. Next will be the TG3 future PHY. It is going close to the situation of 802.11 standard which contains common MAC and multiple PHYs: FH, DSSS, 802.11b, 802.11a. The problem of co-operation of different PHYs with a single MAC has been resolved by creating for each specific PHY a Physical Layer Convergence Procedure (PLCP) sub-layer, which has a generic interface to MAC.

3.2. Proposition

It is suggested to split the 802.16.1 Air Interface document (with one MAC serving two PHYs) explicitly into

- MAC part that will be free from PHY specific issue having instead a generic definition of an interface to PLCP services.
- PLCP = PHY Convergence Layer Procedures (similar by the nature to the ones in 802.11)

- TG1-Mode A PLCP sublayer
- TG1-Mode B PLCP sublayer
- A PLCP sublayer for the HUMAN, suitable for 802.11a/HIPERLAN2-like OFDM PHY
- Three PHY parts:
 - TG1-Mode A
 - TG1-Mode B
 - HUMAN-suitable for 802.11a/HIPERLAN2-like OFDM PHY

Thus there will be a possibility to add more PHYs as needed.

PLCP functions and PHY Layer Related Primitives should be defined for communication MAC \Leftrightarrow PHY, MAC \Leftrightarrow peer MAC etc. These primitives will reflect the services provided by PHY to MAC and possibly from PHY to MAC (like propagation delay compensation or power management feedback).

3.3. Parameters and Constants

3.3.1. General

Change the paragraph 2.2 [1] Parameters and Constants (Table 2— Parameters and Constants) to the table of 802.16 MAC MIB parameters. Add to each PLCP Sublayer description a table with the values of PHY specific parameters.

3.3.2. Clean out the explicit usage of PHY parameters from the MAC part of TG1 document

Examples:

1. “The length of the preamble is 72 QAM symbols” – 2.6.1.
2. “In this particular case, each transmission associated with different SSs is required to start with a short preamble for phase re-synchronization.” – 2.6.4

(there are more)

3.3.3. Remove PHY Parameters from “Configuration File and Registration Settings” to PLCP Part(s)

Example: [1], 2.3.3.1.3/4 SS Demodulator/Modulator Types in the topic “Registration-Request/Response-Specific Encodings”

In such parts as

- Configuration File (SS registration requests)
- “Dynamic Service X” Messages (and other messages concerning PHY parameters)

we need a definition of generic information element(s) that carry PHY specific information [Rate (coding, modulation), frequency, Power management parameters?

Frequency/Clock/Symbol/Synch accuracy?...]. These elements will be then defined differently at the PLCP parts for different PHYs.

3.4. Frame Structure

3.4.1. PHY Frame Structure

1. Redefine the PHY frame structures (see e.g. [1], 2.6.1.3 “Time Division Duplexing (TDD)”) in clearly MAC terms. This includes a replacement for the specification of

- involved PHY parameters. Example: bursts with different types of *QAM modulation* at Figure 51 in [1] should be changed to bursts with different *PHY parameters*.
2. Make the messages related to frame structure (like DL-MAP) PHY-independent. Note that some PHYs have “more parameters” and need more support from MAC than TG1 PHY.
 3. Definition of the Uplink Channel Descriptor attributes including the Physical Layer Burst Profile Parameters (UCD message in 2.5.2.1) should be removed to PLCP part(s) leaving in the MAC only a generic format of the UCD message
 4. The same should be done for Downlink Channel Descriptor
 5. Redefine correspondently the PHY Control portion of the downlink subframe at 2.6.4.1.
 6. Reconsider “PHY Synchronization” issue ([1], 2.5.3) and the relevant messages to make them suitable for a “Generic PHY”
 7. The measurement functions, such as delay, frequency offset and power measurement functions should be described in generic terms applying to PLCP top interface (See [1], 2.5.5, 2.5.6, 2.11.6-2.12.6).

3.4.2. MAC Frame Structure

8. Reconsider the MAC Control portion of the downlink subframe in 2.6.4.1. Time unit(s) should be redefined as PHY-independent. Compare this to the time units used in MAP messages:

“The available bandwidth in both directions is defined with a granularity of one PHY slot (PS),” (2.6.1)

“The upstream bandwidth allocation MAP (USL-MAP) uses time units of “mini-slots.” (2.6.6.1.2)

9. Tx/Rx, Rx/Tx gaps and possibly duration of inter-burst gaps or mid-ambles should be defined in the same units. See [1], 2.6.1.3, 2.6.4, 2.6.5 and definition of DCD and UCD messages

3.5. Constants and Content of Messages Related to Performance, Delays, QoS

3.5.1. Frame Length

See Frame Length options in PHY Synchronization topic, [1], 2.5.3: 0.5, 1, 2 milliseconds. The TG3 type of applications obviously requires flexible frame size that may change from frame to frame, dependently on bit rates and granularity of the capacity allocation.

Suppose we transmit from a CPE to BS using the rate 4 Mbps. Then for 1 ms we may transmit 4000 bits. If the DL/UL ratio is 3:1 and only 50% is actually used by the given CPE (overheads etc.), then we may transmit only 1000 bits per frame that is 12 times less than the Ethernet packet of maximum length and 3 to 5 times less than the “typical” packet.

Tradeoff about the frame length is between the overheads (frame map, fragmentation etc.) involved and the data delivery delays, especially the latency in the recognition of uplink demand.

We need to employ here a possibility to change the frame's size and to change it quickly.

3.5.2. Time Related Parameters

See e.g. 2.5.23 "Downlink Burst Type Change Request (DBTC-REQ) Message"
[Map relevance, ACK timeout etc.]

4. TG3 Specific Features to Be Added

This paragraph contains the examples of the functions to be added to the MAC because of TG3 specific application or other requirements.

4.1. Features Related to the Expected Differences in PHY

Reconsider the MAC Control portion of the downlink subframe in 2.6.4.1. Time unit(s) should be redefined to serve certain frame size quantization vs. bit rate options. The resolution should be sufficient to avoid serious padding overhead for Ethernet frames (of the size typical for IP applications). See e.g. [1], 2.1.1.2.

4.2. Dynamic Rate (Power?) Control

Because of the potentially more fast (comparatively to the frame length) changes in the propagation conditions (multipath at considerably low Radio frequencies) we need an additional mechanism to support more dynamic, ideally per packet, changes in the bit rate (power?) for communication to a CPE.

Compare this to the definition of the corresponding function at [1], 2.5.2.1: "An Uplink Channel Descriptor shall be transmitted by the BS at a periodic interval to define the characteristics of an upstream physical channel. A separate UCD Message shall be transmitted for each active uplink". Such a function is suitable for a small number of the uplink channels with slowly changing conditions but not for the large number of channels with sporadic activity and low duty cycle.

4.3. Features Related to Implementation Complexity

"The target markets to be addressed by the 802.16.3 protocols in BWA networks are single family residential, SOHO, small businesses and multi-tenant dwellings" ([2], 1.2).

This type of application may have hundreds of CPEs attached to a single BS. In this case a centralized decision on the structure of every PHY burst of every CPE may require too much computing power at BS. It is more safe to keep a possibility for a CPE to decide how to use the given transmission opportunity.

4.4. Features Related to the Lower Channel Quality

The following are the reasons why we have to be ready for lower channel quality and less stable channel conditions than in the applications that fit TG1 PAR (see also [5])

- Cheap CPEs with less budget to installation and less possibilities for an operator to place better antennas at proper places
- Lower Radio frequencies together with possible in-door deployment imply multipath interference
- Inter-cell interference in mass cellular deployment
- [HUMAN] Interference because of sharing the medium with e.g. “hidden” 802.11-UNII band terminals and simply non-IEEE devices

Above reasons may essentially increase BER so that the FER (Frame Error Rate) might go as high as to several percents. This triggers the higher layers retransmissions which impact negatively on the TCP applications (very sensitive to the delay variations and packet loss). So additional functions needed to fight against these problems, such as

- **MAC Level ARQ** including (see comment at [1], 2.5)
 - Checksum definition for a fragment
 - ARQ Feedback concept (ACK, NACK, ACK timeout, interaction with Convergence Layer entities, ...) and the coding of the correspondent messages
- **Dynamic Rate Control (per packet)**, clearly associated in implementations with ARQ (packet failure requires retransmission at lower rate etc.)
- **Transmit Power Control**, designed to deal with long no-transmit periods and fast recovery. Possible solution could be, for example, a “RNG-RSP”-like packet sent by a BS as a response to an uplink packet ad BS’s discretion.

4.5. Features Related to Specific Traffic Demand Statistics

The following paragraph describes the traffic demand characteristics expected in the considered by [2] types of applications. For the residential and SOHO deployment the Internet access obviously becomes the most important if not a dominant application.

Possible solutions for the specific problems are briefly sketched.

4.5.1. Expected Traffic Demand Features

4.5.1.1. Numerous Streams with Low Duty Cycle

4.5.1.1.1. Problem

The total demand per Base Station (sector) is an integration of numerous (tens or even hundreds) streams passing to/from CPEs.

Each stream might expose both continuous and discontinuous (bursty) demand. In the latter case the demand might be triggered by an arrival of a single upper layer PDU such as an IP datagram encapsulated into an Ethernet packet. Demand duty cycle might be very low, especially for residential subscribers. For example, such a subscriber might require data transfer once in a minute, during few seconds only. See [3] for more details.

Compare this with [2], 7.3: “802.16.3 protocols SHOULD include a mechanism that can support dynamically-variable-bandwidth channels and paths (such as those defined for IP environments)”.

Thus the total uplink demand is a composition of a large number of small elementary

This implies a specific problem of the fast recognition of UL demand.

4.5.1.1.2. Possible Solution

This problem needs further study.

One of the possible solutions is to employ contention-based data frame transfers with exponential Backoff (as in 802.11 DCF).

Another solution may be based on the “Fast Polling” mechanism when each CPE is choosing to transmit in some of small contention slots chosen according to some binary code so that the BS can reduce further polling to a small subset of the associated CPEs.

One more solution is to employ some sort of slotted fragmented data contention instead of slotted Bandwidth Request

Perhaps more solutions might be proposed.

To implement any of these solutions, small time slots are to be defined in the MAC together with small PDUs (bursts) that can be transmitted within one slot. Additionally, the function of propagation delay compensation is needed to synchronize all uplink transmissions to the slot boundaries.

4.5.1.2. Statistics of Packet Sizes

See e.g. [4] for the statistics of packets' sizes in the Internet: 60% of the packets are < 200 bytes and 80% of packets < 600 bytes. This statistics is expected to be valid also for the demand of residential and similar CPEs. This calls for lowering the overheads in MAC messages and in allocation granularity.

So the problem is to provide a mechanism for allocation to a large number of small independent data units in both DL and UL directions.

5. General Comments

The following issues should be clarified concerning TG1 changes to the direction desired for TG3. This is especially important for the residential (SOHO) because we have here considerably small bursty demands with low duty cycle. So it might happen that we would need a definition of the QoS parameters and/or the QoS related behavior that will be different from the one suitable for large aggregations of individual traffic demands. Sometimes we may need simply a more accurate definition. Examples:

1. Rate (Token bucket def) should be defined as a “capacity available on demand”, not as bit rate itself (what if the demand is less than committed value?)
2. Behavior of the MAC to keep the parameters within the given boundaries (priorities among them? What happens in the case of failure?)
3. Support for multicast-based services like video distribution (see [1]. 2.5.20) .

These and similar issues need to be analysed.